City of Arlington Texas

NONPOINT SOURCE POLLUTION

A MANUAL FOR THE JUNIOR HIGH SCHOOL TEACHER

NONPOINT SOURCE POLLUTION

Produced by the
Storm Water Quality Program
Department of Engineering Services
City of Arlington, Texas

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A Manual for the
Junior High Science Teach

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ADDITIONAL COPIES

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GRANT SUMMARY

The purpose of this grant project is to encourage the junior high science educators in the Arlington Independent School District (AISD) to incorporate water quality issues in their classroom curriculum. The focus of this project is on nonpoint source pollution related to storm water quality. Each junior high school in the AISD will receive a copy of this manual, water quality testing equipment, supplementary videos and other material for in-class use. A workshop explaining the use of the manual and testing equipment was conducted for the science coordinators of the ten junior high schools.

Legislative Background

On October 18, 1972, the congress of the United States enacted the Federal Water Pollution Control Act Amendments,. This is the official title of the legislation usually referred to as the Clean Water Act (CWA). Since 1972, the policy within the United States concerning water quality has been based on four basic ideas:

1. **No one has a right to pollute the navigable waters of the United States.** Anyone wishing to discharge pollutants must obtain a permit to do so.

2. **Permits shall limit the composition of a discharge and the concentration of the pollutants in it.** Violation of permit conditions are subject to fines and imprisonment.

3. **Permit conditions may require the best controls technology can produce, regardless of the receiving water's ability to purify itself naturally.** Some levels of pollution control are actually worth their cost.

4. **Any limits or controls higher than the minimum federal requirements must be based on receiving water quality.** The only way to impose stricter standards than those of the CWA is to demonstrate that continued protection of the receiving waters demands such limits.

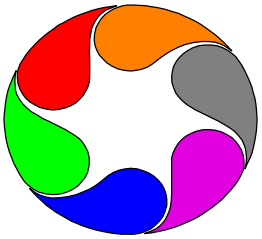
At the inception of the CWA in 1972, the major water pollution concerns were untreated or inadequately treated sewage from municipal sources and insufficiently treated discharges of industrial wastewater. These point sources (from a single pipe or location) were permitted and dischargers had permit limitations concerning types and quantities of pollutants. Although the major point sources were identified and regulated, many rivers and streams were still polluted and not meeting water quality criteria. The pollution was from unknown sources.

The remaining pollution threatening our water quality was attributed to nonpoint source pollution (NPS). Nonpoint source pollution results from rainfall runoff, atmospheric deposition, drainage, seepage, and hydrologic modifications. In urban areas nonpoint source pollution is created when sediment, toxic substances, nutrients, pathogens, and garbage wash off fields, lawns, and impervious surfaces into our nation's waterbodies. Revision of the CWA, 1987, recognized NPS as the remaining primary source of stream pollutants and established new regulations concerning this problem. The 1987 amendments set deadlines for cities, industries, commercial businesses and construction activities to obtain permits for storm water runoff. To obtain these permits, cities were required to sample for NPS pollutants during wet and dry weather conditions. Cities also have to provide to the U.S. Environmental Protection Agency (USEPA) a storm water management program implementing best management practices to the maximum extent practicable to achieve acceptable water quality. The aim of the CWA is “fishable, swimmable waters."

Storm drainage systems are found in every major city. Storm drains are designed to collect and convey storm water away from streets, homes and other property to a waterway. Natural creeks, underground pipes and open channels are all components of the storm drain system. Water flowing into the storm drainage system can transport pollutants. Since components of these systems are located throughout a city, pollution from illegal dumping, accidental spills, industrial waste and numerous other sources can easily enter them. Pollutants then flow to streams, rivers or lakes. Nonpoint sources are difficult to identify or control because of their wide distribution and the complexity of the storm drainage system.

Arlington, Texas, along with other cities in the United States will be issued permits by the USEPA to discharge their storm water to the waters of the United States (streams, rivers and lakes). This permit will obligate the city to reduce nonpoint source pollution. Cities have several choices in reducing NPS pollution. One is the treatment of storm water in a manner similar to wastewater treatment. Treating storm water would be extremely costly, therefore, most cities are choosing to reduce NPS pollution at the source rather than with end of the pipe treatment.

WATER



WATER FACTS

- the most abundant and important substance on earth
- covers nearly 3/4 of the earth's surface
- present in the atmosphere and the earth's crust
- only substance that occurs naturally in three physical states liquid, gas, and solid (water, water vapor and ice)
- odorless, tasteless, colorless and transparent in its pure liquid state
- a universal solvent
- 2 hydrogen atoms and one oxygen atom
- about 70% of the human body is water
- a large portion of humans and all living material
- people need almost 2 gallons of water a day to satisfy biological needs
- essential to life
- makes all biological functions possible
- the United States uses about 400 billion gallons of water each day
- it takes about 70 gallons to make just 1 gallon of gasoline
- more than half of the American population gets its water from underground sources or aquifers
- one gallon of gasoline can contaminate 250,000 gallons of water

LIFE IN WATER

- green plants in water such as algae obtain their food from photosynthesis. These aquatic plants oxygenate the water during the day, adding oxygen being produced as a byproduct of photosynthesis.
- algae and phytoplankton are eaten by zooplankton, microscopic animals, which are eaten by larger organisms such as fish or invertebrates. This is the basis of the food chain in aquatic environments.
- The food web in most aquatic systems has the following structure:

  carnivores..... 3%
  herbivores..... 10%
  plants..... 87%

WATER SYSTEMS

WATERSHEDS

Watersheds are geographic regions that drain surface water towards a particular water body, such as a stream or a lake. Water flows from the higher regions of the watershed to the lower regions. A ridge or other area of elevated land separates one watershed from another. Streams and rivers function as the arteries of the watershed. As water flows over a watershed, it can either go into a waterbody such as a stream or soak into the soil to become groundwater. The process of water percolating through the soil may remove impurities such as oil, grease or bacteria from the water by filtration, absorption or adsorption.

STREAMS AND RIVERS

Flow in streams originates from rain water, springs (groundwater) or snowmelt. Rivers are large natural streams that return surface waters to the ocean.

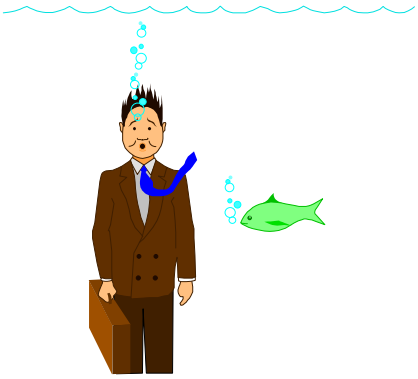
PONDS

Ponds are usually man-made, but may develop where streams have stopped flowing through old channels or where deposits of soil prevent water from entering channels. Ponds are quiet, small bodies of water that are usually shallow enough that rooted plants grow throughout the pond.

LAKES AND RESERVOIRS

Lakes are formed when streams are dammed naturally or artificially, causing water to collect in large pools. The water is too deep for plants to grow except around the shoreline. Naturally formed bodies are lakes. Man-made lakes in which water is stored for future use are called reservoirs. Lake Arlington is a reservoir.

WATER POLLUTION



Many types of pollution affect water quality. Observable signs of water pollution include discoloration, unpleasant odor, excess algae growth, cloudy or silty water or dead fish, plants or animals. All sources of water pollution may be classified as point and nonpoint.

POINT SOURCE POLLUTION

Water pollution that can be traced to a single source or location is called a point source. Usually point source discharges enter waterways through a single pipe. Examples of point sources are discharges from industrial plants and sewage treatment plants. Point sources are easily identified and have been targeted by legislation for regulation. All point source discharges must have a National Pollution Discharge Elimination Systems (NPDES) permit. These point sources require monitoring of the discharge to ensure that the water quality is not impaired. Usually biological or chemical treatment is used prior to wastewater being discharged from point sources.

NONPOINT SOURCE POLLUTION

Nonpoint source water pollutants can be diffuse, coming from a large area. Hence, the origins are not easily identified or controlled. NPS pollution occurs when water flows overland and enters a storm drain or a waterway. The water can come from rainfall, watering the lawn, groundwater seepage, irrigation, or other sources. The rain water is not initially polluted but comes in contact with pollutants. As water flows over the land, many substances associated with that land area become a NPS pollutant. Examples of NPS pollutants are sediments, organic wastes, bacteria, fertilizers, pesticides, toxic waste, hazardous wastes, oil, grease, trash and anything that can be washed away by water. All types of land uses and activities can contribute to nonpoint source pollution.

As more and more land in a watershed is covered with impervious surfaces, such as concrete and asphalt, water that previously infiltrated into the soil now flows over the land directly into streams and other drainage systems. This increased flow of water can impact water quality in several ways. Pollutants are often removed when water passes through the soil. Urban development decreases the amount of pollutants removed in this manner, thus more pollutants find their way into the streams along with greater volumes of water. This increased stream flow may also cause flooding problems or the erosion of the stream banks. Increased water velocity can tear out vegetation, thus creating more of an erosion problem. With the loss of vegetation, aquatic organisms may lose their habitats.

TABLE 1:POLLUTANTS AND THEIR SOURCES

	BOD[1]	BACTERIA	NUTRIENTS	AMMONIA	TURBIDITY	TSS[2]	ACIDS	TOXICS
POINT SOURCE								
MUNICIPAL SEWAGE TREATMENT PLANTS	●	●	●	●	●			●
INDUSTRIAL FACILITIES	●		●	●	●		●	●
SEWER OVERFLOWS	●	●	●	●	●	●		●
NONPOINT SOURCE								
AGRICULTURAL RUNOFF	●	●	●	●	●	●		●
URBAN RUNOFF	●	●	●		●	●		●
CONSTRUCTION RUNOFF			●		●	●		●
MINING RUNOFF					●	●	●	●
SEPTIC SYSTEM	●	●	●	●	●			●
LANDFILLS LEACHATE	●							●
RAINFALL							●	

[1] Biochemical oxygen demand
[2] Total suspended solids

TABLE 2:

SOURCES AND ASSOCIATED POLLUTANTS

SOURCE	COMMON ASSOCIATED CHEMICAL POLLUTANTS
CROPLAND	Turbidity, phosphorus, nitrates, temperature, total solids
FORESTRY HARVEST	Turbidity, temperature, total solids
GRAZING LAND	Fecal bacteria[3], turbidity, phosphorus, nitrates, temperatures
INDUSTRIAL DISCHARGES	Temperature, total solids, toxics
MINING	alkalinity, total dissolved solids, acidity
SEPTIC SYSTEMS	Fecal bacteria, nitrates, phosphorus, BOD
CONSTRUCTION	Turbidity, temperature, BOD, total solids, toxics
URBAN RUNOFF	Turbidity, phosphorus, nitrates, temperature, BOD, detergents

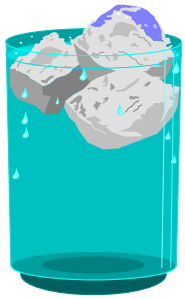
TABLE 3:

SOLUTIONS TO NONPOINT SOURCE POLLUTION

POLLUTANT	SOLUTION
SEDIMENT	Sweep walkways, driveways, etc. Place a splash guard under a gutter downspout. Plant trees, bushes, grass to encourage water infiltration. Store piles of sand or gravel on soil, cover with plastic.
NUTRIENTS	Use fertilizers only when necessary, follow label instructions and do not over water or apply before rain. Do not dump leaves, grass or other organic material in the storm drains or waterways. Try composting.
TOXIC METALS	Carpool, or use public transportation Dispose of old auto batteries at a hazardous material collection day or leave at vendor of replacement batteries. Use rechargeable batteries. Recycle used car fluids (oil, antifreeze, etc.)
ANIMAL WASTE	Scoop it up. Don't let your pet "go" near a waterway.
PESTICIDES	Try biological controls. Follow label instructions. Do not apply when rain is forecast.

[3] *Escherichia coli*, *Escherichia enterococcis*

CONSTITUENTS OF WATER QUALITY



TEMPERATURE

Temperature is an important part of any aquatic system. All biological and chemical reaction rates are dependent on temperature. Aquatic organisms are also dependent on certain temperature ranges. Benthic macroinvertebrates, fish, and other aquatic organisms all have optimal ranges of temperature for growth and reproduction. If the temperature is below or above this range, organisms can become stressed and die.

Temperature directly affects the concentration of dissolved oxygen in water. Warm water cannot hold the same amount of dissolved oxygen as cold water. Therefore, at higher temperatures, there is less available oxygen for aquatic organisms. This contributes to fish kills in area rivers during the summer months. Temperature also influences the rate of photosynthesis and metabolism and the ability to fight disease.

Changes in temperature can be caused by: changes in the weather, loss of shading material, impoundment of water, discharge of cooling water from industrial sites, urban storm water and groundwater inflows.

CHLORINE

Chlorine is particularly toxic to the microorganisms. Therefore, chlorine is used for disinfection purposes. Residual chlorine contained in discharges can render aquatic systems sterile. In Texas, discharges from wastewater treatment plants must now be dechlorinated before release to aquatic systems.

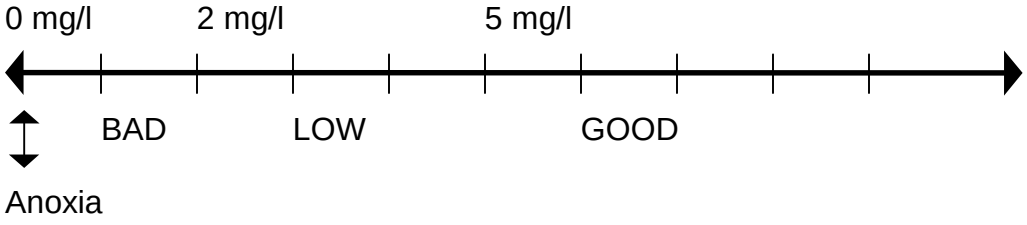
Chlorine can enter storm water systems from illicit connections, the water distribution system or the discharge of swimming pool water. Chlorine, when highly diluted, rapidly dissipates in most aquatic systems which reduces its toxicity.

DISSOLVED OXYGEN (DO)

Dissolved oxygen is necessary for the majority of plants and animals. There are a few exceptions that require little or no oxygen, which are classed as anaerobic. The aquatic oxygen comes from two sources: the atmosphere and photosynthesis. Agitation of the water surface by winds and waves increases the amount of atmospheric oxygen that is diffused into the water. During daylight, plants through photosynthesis contribute oxygen to the surface waters which become often supersaturated. This surplus of oxygen is utilized at night. All organisms that require and consume oxygen for respiration produce carbon dioxide. Since plants do not release oxygen during the night, the DO concentration can drop sharply in aquatic systems during the night. Low concentrations of DO decrease the ability of the aquatic systems to support the majority of living organisms. When DO levels drop below threshold levels organisms have limited options. Mobile organisms move and immobile organisms often die.

As stated before, temperature strongly influences the amount of dissolved oxygen available in water. Water that is at 32^{o}F, when supersaturated with oxygen, can hold 14.6 milligrams per liter (mg/l) of oxygen. This is the maximum amount of oxygen that any water system can have. Levels under 3 mg/l will stress the organisms, and mobile species generally will leave the area. DO levels in aquatic systems under 0.5 mg/l result in death for any organisms requiring oxygen.

Salinity and atmospheric pressure also affect DO concentrations. Salinity is not an important consideration in freshwater systems. High levels of minerals dissolved in water reduce the water's capacity to hold oxygen. High altitude water systems (such as high mountain lakes) with lower atmospheric pressure experience a decrease in the solubility of oxygen in water.

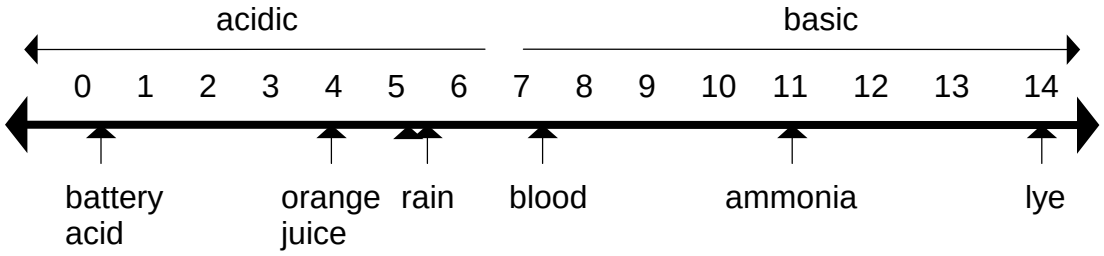


Anoxia is defined as the absence of oxygen, with DO levels being measured at less than 0.5 mg/l. Hypoxia is defined as low oxygen levels with DO levels in the range of 2 mg/l to 5 mg/l.

Other factors affecting DO concentrations are excess organic material such as sewage, leaves or grass clippings. The natural decomposition cycle may become overloaded. The bacterial populations will increase in the nutrient rich environment and can deplete the DO. The amount of oxygen required by bacteria to break down the organic material is referred to as biological oxygen demand (BOD). When the BOD of the organic material exceeds the available oxygen, the DO in the water is reduced or depleted and becomes insufficient for most organisms. Also, excess nutrients, such as nitrogen and phosphorus which are usually limiting nutrients, can cause an increase in the phytoplankton population.

pH

The concentration of the hydrogen ion is a measure of the acidity or alkalinity of a solution. The concentration of the hydrogen ions expressed in terms of its negative logarithm is known as the pH. Pure water's pH is 7.0. Solutions with a pH less than 7.0 are acidic, solutions with a pH of greater than 7.0 are basic and 7.0 is neutral. Values of pH are based on the logarithmic scale to the base of 10. Therefore, a change from 4.0 to 3.0 in pH represents a ten fold increase in acidity.



Buffering capacity is the ability of water to resist a change in pH. This ability is important to aquatic organisms. Most aquatic organisms are adapted to a pH range between 5.0 and 9.0. Photosynthesis can influence pH. Carbon dioxide removed from the water can increase pH. Some pollutants that may affect pH are lime, caustic soda, pesticides, fertilizers and domestic sewage. Table 4 presents some of the effects upon the aquatic environment at various levels of pH.

TABLE 4:

EFFECTS TO THE AQUATIC ENVIRONMENTS DUE TO pH

pH RANGE	EFFECTS
11.5 to 11.0	Lethal to all fish species.
11.0 to 10.5	Prolonged exposure lethal to carp, perch.
10.5 to 9.0	Likely to be harmful if present for lengthy duration.
9.0 to 8.0	Not directly harmful, can cause chemical changes.
8.0 to 6.5	Optimal for most organisms, some species will be eliminated. Change of 0.5 pH unlikely to cause long term damage, decrease of 1.0 pH can alter the biotic community.
6.5 to 6.0	Freshwater shrimp absent.
6.0 to 5.5	Reduction in species number, remaining species subject to stress. Bacterial decomposers will die. Plankton numbers will decrease.
5.5 to 5.0	Number and diversity of species will be reduced, many species will be eliminated. Metals trapped in sediments are released in acidic water in forms toxic to aquatic life.
5.0 to 4.5	Decomposition of organic material may be impaired. Most fish eggs will not hatch. Many insects absent.
4.5 to 4.0	Most fish, most frogs and all insects will be eliminated.
4.0 to 3.5	Lethal to salmonids.
3.5 to 3.0	Fish will not survive for more than a few hours. Some plants and invertebrates present.

NUTRIENTS

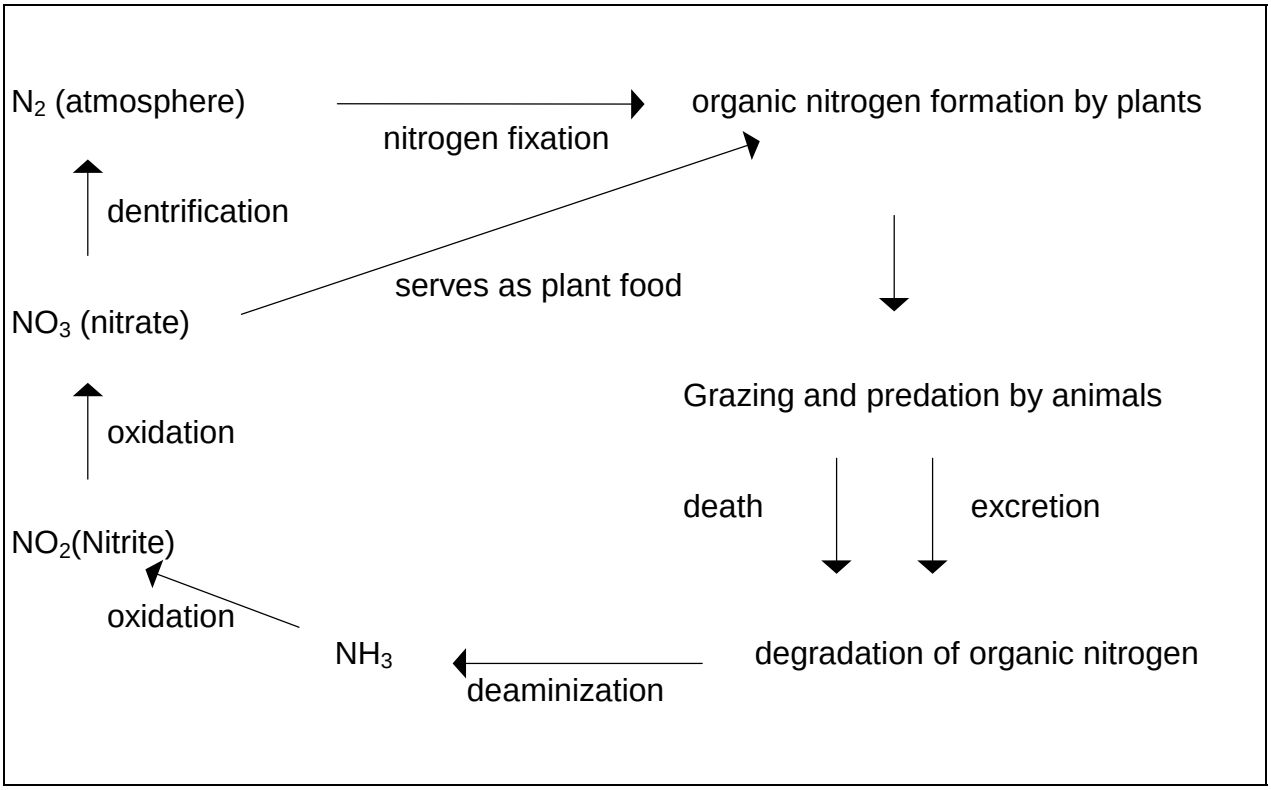
Nutrients are chemical substances that living organisms use for maintenance and growth. They are required for survival. Like land plants, aquatic plants require nitrogen and phosphorus. Nutrients that are usually low in concentration in nature are referred to as limiting nutrients, as they limit the number of plants in a system. Excessive concentrations of these limiting nutrients in an environment can trigger an over abundance of plant growth. This is called a bloom. An algal bloom can be a serious problem in aquatic systems. The excessive algal population can deplete the DO concentration at night and shade the water during the day, thereby reducing photosynthetic activity. This can cause oxygen depletion and stress in aquatic organisms.

Nitrogen

Nitrogen is found in three forms: ammonia (NH_3), nitrates (NO_3) and nitrites (NO_2). Excess nitrates can cause hypoxia and can become toxic to warm blooded animals in high concentrations (>10 mg/l). The natural level of ammonia or nitrate in surface water is 1 ppm (parts per million is equivalent to milligrams per liter). Ammonia nitrogen is toxic to freshwater aquatic organisms in a range of 0.2 to 4.8 ppm.

Ammonia nitrogen is produced by deamination of organic nitrogen containing compounds and by hydrolysis of urea. Deamination is the process of removing an amino group from organic nitrogen. Sources of ammonia can be from the sanitary sewer, malfunctioning septic systems and wildlife fecal matter, especially large number of ducks and geese.

NITROGEN CYCLE

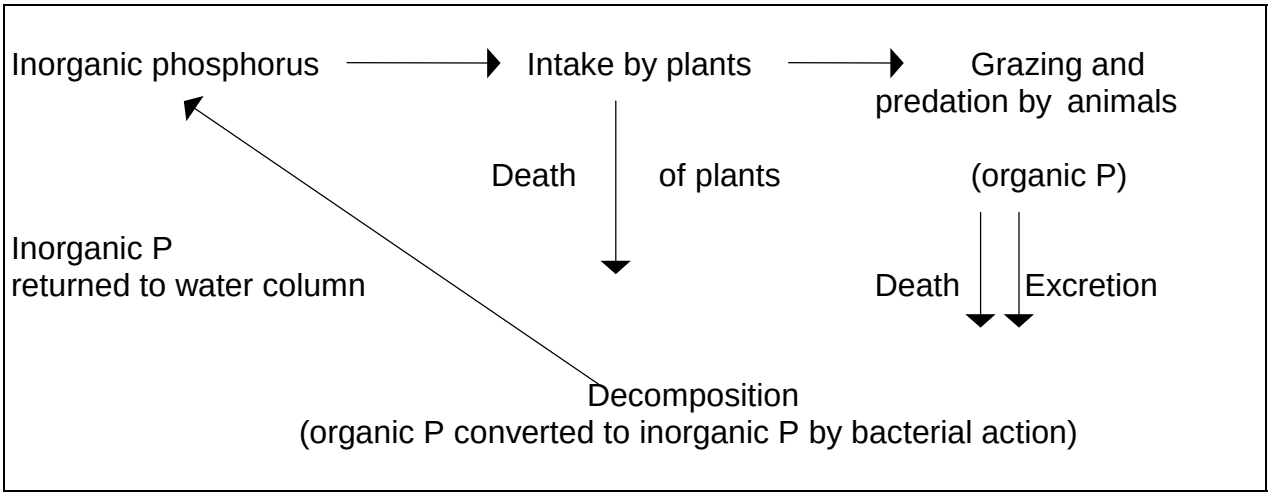


Phosphorus

Phosphorus occurs naturally in such low concentrations in aquatic systems that even a small increase can set off a whole chain of undesirable events. Among these undesirable events are accelerated plant growth, algae blooms, low DO and death of some fish, invertebrates and other organisms. Phosphorus is found in soil, rocks, wastewater treatment plant discharges, runoff from fertilized lawns and croplands, runoff from animal manure storage areas, drained wetlands, water treatment and cleaning products.

Phosphates, chemical compounds that are made from the element phosphorus, are sometimes used in detergents and fertilizers. Phosphates in our wastewater are often not removed by sewage treatment processes.

PHOSPHORUS CYCLE



DETERGENTS

Detergents can be toxic to many aquatic plants, insects and fish. Detergents can lower the amount of dissolved oxygen available to fish and other aquatic organisms due to the biodegradation of the detergent. Microorganisms such as bacteria will use the detergents as a food source. Bacterial blooms, similar to aquatic plant blooms, can occur from bacterial use of detergents as a food source. Increases in the bacterial population create a new demand on the dissolved oxygen. Detergents can also alter the pH of the water system.

Many products are listed as being "biodegradable." Biodegradability does not translate into "permission" to dump these substances in an aquatic system. All that biodegradable means is that living organisms or environmental conditions will degrade or break down these products naturally. Any upset in the balance of an aquatic system will create changes, and many times these changes are not positive.

Detergents usually enter the storm water system from illicit discharges to the storm drainage system. The City of Arlington and other cities around the nation have found that a high percentage of the water in the streams, or that flowing from the outfalls of the storm drain system, contain detergents. Some detergents may enter the water systems from sanitary sewer leakage. The cleaning of cars, parking lots, buildings and numerous other items with detergents and allowing the wash water to flow into the storm drainage system is another significant source of detergents.

OTHER

Fecal Bacteria

Fecal bacteria or fecal coliform bacteria are used as indicators of human waste or sewage in a water system. Fecal bacteria are found in human and animal digestive systems. These bacteria are generally not harmful, but do indicate the possibility of pathogenic bacteria, virus or protozoa in the water. Sources of fecal bacteria in surface water include wastewater treatment effluents, septic systems, animal manure, overflows from the sanitary sewers and storm water runoff. Fecal bacteria not only are a concern for health reasons but can also impact surface water quality by increasing cloudiness, creating unpleasant odors and contributing to low DO.

Litter And Trash

Litter on the road, materials spilled or overflowing from garbage cans or dumpsters, parking lot trash, illegally dumped tires or roofing shingles, grass clippings and tree leaves are all examples of pollutants. During rains or high winds, these items can enter the storm drains or streams. Floatables, trash and litter that float, are not only aesthetically undesirable, but they may also be damaging to our water systems. Floatables can collect and may cause flooding. Some fish, birds and other wildlife can be seriously harmed by plastic items in the environment.

Sediment

Sediment is composed of small particles of soil that are picked up and carried by water flowing over land. Most sediment comes from the erosion of agricultural lands, surface mines and construction areas. Sediment in water gives the water a muddy appearance. Excessive sedimentation is not only an aesthetic consideration. The sediment particles in the water column can reduce the amount of light penetrating through the water, thus reducing the amount of photosynthesis. As green plants form the base of the food chain, or food web, this can reduce the productivity of the entire system.

Sedimentation occurs when the velocity and turbulence of the flowing water no longer have the energy to transport the suspended sediment. When the sediment settles out of the water column, the sediment covers the bottom of the lake or stream. This can alter the natural habit and affect the benthic organisms' environment. Sediment can also impact the fish population by reducing the area suitable for spawnings and damaging their gills.

The sediment input into a water system can be greatly accelerated by human activities. All lakes will eventually fill with sediment over time, but the extra loading of sediment and the early "death" of a lake can be hastened by human activity. In general, the amount of material deposited in a lake or channel is directly related to the land use in the watershed. Activities that clear the land of vegetation and expose soil to winds and rain greatly increase the potential for erosion. Erosion can also lead to flooding problems. The sediment deposited in a section of channel or stream reduces the amount of water that can flow through that section. If water flow is greatly reduced, this could result in flooding.

Toxins And Hazardous Wastes

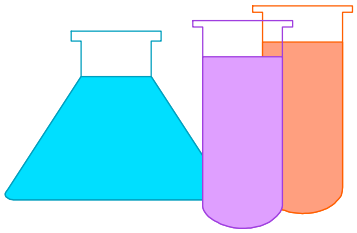
Toxic substances act as poisons. Toxic substances that can cause immediate problems are referred to as acutely toxic. If the toxic substance causes long term effects such as an alteration in metabolism, reproduction, or other biological activity, the toxin is classified as having chronic toxicity. Examples of toxic materials are metals such as copper, mercury, nickel, chromium, zinc, lead and chemicals such as those found in pesticides.

Bioaccumulation is when a toxin, in a low concentration in the environment, does not have any immediate effect on the primary consumers, but its toxicity becomes apparent in the secondary and tertiary consumers. The predators obtain the sum of the toxic material found in the smaller organisms. With bioaccumulation, the organisms on top of food chain consume a higher concentration of the toxin which may then be detrimental to life. In some Texas cities, the Texas Department of Health has established bans on consumption of

the fish caught in ponds and major waterways. Citizens are urged not to eat the fish from these aquatic systems due to bioaccumulation of toxic materials in their tissues.

Hazardous materials are any materials that pose a risk or threat to people or the environment when not disposed of properly. Storm water systems can be contaminated by direct dumping of hazardous wastes into storm drains, aquatic systems, or by leaching into groundwater from landfills and other sources. Not all hazardous wastes are generated from industrial activity. Some are found in every home in the country. Household hazardous wastes include detergents, paints, degreasers, insecticides, fertilizers, metal polishes, oven cleaners, wood polishes, antifreeze, motor oil, transmission fluids, paint strippers and many other products. All hazardous materials need to be disposed of properly. It is essential to read all label instructions concerning disposal. If there is any confusion concerning disposal, keep your household hazardous waste until there is a community hazardous waste collection day where the waste will be collected and disposed of properly.

METHODS



TEMPERATURE

Measure temperature as follows:

1. Place the thermometer in the water so that at least 3 inches of the thermometer is below the water surface.
2. Allow enough time for the thermometer to reach a stable temperature (at least one minute).
3. Read the thermometer with the bulb beneath the water surface. Each mark on the thermometer is equivalent to 2 degrees Fahrenheit. Read the temperature to the nearest mark.
4. Record the temperature.

pH

Measure pH as follows:

1. Dip the portion of the pH strip with 4 color bands in the water sample.
2. Keep the strip in water sample until there is no further color change.
3. While the strip is still moist compare the colors on the end of the strip to the colors on pH strip container box.
4. Record the pH value matched.

The methods on the following pages are reprinted with permission from the instructions in the LaMotte Test Kit purchased from:

LaMotte Company
P.O. Box 329
Chestertown, Maryland 21620
1-800-344-3100.

CHLORINE (LaMotte DPD Free, Total & Combined Chlorine Test Kit #3308

The Octa-Slide Viewer should be held so non-direct light enters through the back of the comparator. With the sample tube inserted at the top, slide the Octa-Slide through the viewer and match the sample color with a color standard.

PROCEDURE

Free Available Chlorine

1. Fill a test tube (0101) to the 10 ml line with sample water.
2. Add one DPD #1R Tablet (6999). Cap tube and shake until tablet disintegrates.
3. Immediately insert tube into the top of the Octa-Slide Viewer (1100). Slide the Octa-Slide (3401) into the viewer. Match sample color to a color standard. Record as ppm free available chlorine. Retain this sample if total residual and combined chlorine are to be determined.

Total Residual Chlorine and Combined Chlorine

4. Add one DPD #3R Tablet (6905) to the sample from Step 3. Cap and shake until tablet disintegrates.
5. Insert tube into Octa-Slide Viewer. Match sample color to a color standard. Record as ppm total residual chlorine.

Combined Chlorine ppm = Total Residual Chlorine - Free Available Chlorine

DISSOLVED OXYGEN (LaMotte Dissolved Oxygen Test Kit #7414)

DIRECT READING TITRATOR

1. Fill the titration tube to the line with the water sample.
2. Add the reagents as specified in the instructions for the individual test method. Cap the tube with the special titration tube cap. Mix by swirling gently.
3. Depress the plunger of the Titrator to expel air.
4. Insert the Titrator into the plastic fitting of the titrating solution bottle.
5. To fill the Titrator invert the bottle and slowly withdraw the plunger until the bottom of the plunger is opposite the zero mark on the scale.
   NOTE: When filling the titrator from a container not fitted with a special plug, submerge the tip of the titrator below the surface of the solution and withdraw the plunger.
   NOTE: A small air bubble may appear in the Titrator barrel. Expel the bubble by partially filling the barrel and pumping the titration solution back into the inverted reagent container. Repeat this pumping action until the bubble disappears.
6. Turn the bottle right-side-up and remove the Titrator.
7. Insert the tip of the Titrator into the opening of the titrator tube cap. Slowly depress the plunger to dispense the titrating solution. Gently swirl tube to mix. A slight rotating or twisting motion may permit the plunger to move more slowly.
8. Continue adding the titrating solution until the specified color change occurs. If no color change occurs by the time the plunger reaches the bottom of the scale, refill the Titrator to the zero mark. Continue the titration. Include both titration amounts in the final test result.
9. Read the test result directly from the scale opposite the bottom of the plunger.
10. If no additional tests are to be made, discard the titrating solution left in the Titrator. Thoroughly rinse the Titrator and the titration tube.

COLLECTION OF WATER SAMPLE

1. Rinse the Water Sampling Bottle (0688-DO) with sample water (twice).
2. Tightly cap the bottle and submerge it to the desired depth. Remove cap to allow the bottle to fill.
3. Tap the sides of the submerged bottle to dislodge any air bubbles clinging to the inside. Replace the cap while the bottle is still submerged.
4. Retrieve the bottle and examine it carefully to make sure that no air bubbles are trapped inside. Once a satisfactory sample has been collected, proceed immediately with Steps 5 & 6 to fix the sample.
   NOTE: Be careful not to introduce air into the sample while adding the reagents into the sample. Cap carefully and mix gently.
5. Add 8 drops of Manganous Sulfate Solution (4167) and 8 drops of Alkaline Potassium Iodide Azide (7166). Cap and mix by inverting several times. A precipitate will form. Allow the precipitate to settle below the shoulder of the bottle before preceding.
6. Use the 1.0 gram spoon (0697) to add one level measure of Sulfamic Acid Powder (6286). Cap and gently shake until the reagent and the precipitate have dissolved. A clear-yellow to brown-orange color will develop, depending on the oxygen content of the sample.

TEST PROCEDURE

1. Fill the titration tube (0299) to the 20 ml line with the fixed sample and cap.
   NOTE: If the color of the “fixed” sample is already a very faint yellow skip to step 3.
2. Fill the Direct Reading Titrator (0377) with Sodium Thiosulfate 0.025N (4169). Insert the Titrator into the center hole of the titration tube cap. While gently shaking the tube, slowly press the plunger to titrate until the yellow brown color is reduced to a very faint yellow.
3. Remove the Titrator and cap. Be careful not to disturb the Titrator plunger, as the titration begun in Step 2 will be continued in Step 4. Use the pipet (0392) to add 8 drops of Starch Indicator Solution (4170). Sample should turn blue.
4. Replace the cap and Titrator. Continue titrating until the blue color just disappears. Read the test result where the plunger tip meets the scale. Record as ppm Dissolved Oxygen.
   NOTE: Each minor division on the Titrator scale equals 0.2 ppm
   NOTE: If the plunger tip reaches the bottom line on the Titrator scale (10 ppm) before endpoint color change occurs, refill the Titrator and continue the titration. When recording the test result, be sure to include the value of the original amount of reagent dispensed (10 ppm).

NITROGEN

TEST PROCEDURE

1. Fill test tube (0124) to 5 mL line with sample water.
2. Add one *Ammonia #1 Tablet (3968) and one *Ammonia #2 Tablet (3969). Cap and mix until tablets disintegrate. Wait 5 minutes.
3. Facing a source of natural light, hold test tube flat against the white section of the ColoRuler (6665-01). Match sample color to a color standard. Record as ppm Ammonia-Nitrogen.
   NOTE: Sample may be turbid. This will not affect the test results.
4. To convert result to Ammonia, multiply reading by 1.3 Record as ppm Ammonia.

DETERGENTS (LaMotte Detergent Test Kit #4507)

PROCEDURE

Part 1
Determines if detergent is present in the sample.

1. Use the calibrated test tube (0755) to measure 5 ml of the sample solution. Add to the screw cap tube marked Test Sample (0282).
2. Use the 0.25 gram spoon (0695) to add one measure of pH Adjustment Powder (4509). Shake until dissolved.
3. Fill the pipet (0347) with DS Indicator Reagent (4508) by squeezing the rubber bulb, inserting pipet into liquid. Add this amount of DS Indicator Reagent to the Test Sample tube (do not touch sample with pipet tip). Cap and shake for one minute.
4. Allow the tube to stand until the two layers of the solution separate. The water layer will settle to the bottom and the reagent layer will rise to the top.

Use chart below to determine if detergent is present.

BOTTOM LAYER	TOP LAYER	QUICK READING
Colorless	Colored	NO DETERGENT IN SAMPLE
Some Color	Some Color	SOME DETERGENT IN SAMPLE
Colored	Colorless	HIGH DETERGENT IN SAMPLE

NOTE: If the amount of detergent in the sample is to be determined, save this test sample and proceed to Part II.

Part II
Determines the amount of detergent present in the sample.

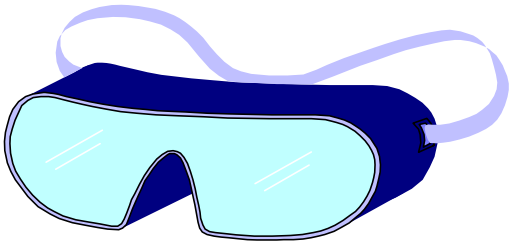
1. Use the calibrated test tube (0755) to measure 5 ml of detergent free water. Add to the screw cap tube marked Reference Sample (0283).
2. Use the 0.25 gram spoon (0698) to add one measure of pH Adjustment Powder (4509). Shake until dissolved.
3. Fill the pipet (0347) with DS Indicator Reagent (4508) by squeezing the rubber bulb, then inserting pipet into liquid. Add this amount of DS Indicator Reagent to the Reference Sample tube (do not touch sample with pipet tip).
4. Add one drop of DS Reference Solution (4513). Cap and shake for one minute.
5. Allow the tube to stand until the two layers of solution separate. The color produced in the bottom (water) layer is equivalent to 1 ppm of detergent.
6. Compare the color in the bottom layer of the Test Sample Tube from Part 1 to the color of the bottom of the Reference Sample tube.

IF TEST SAMPLE COLOR IS	TEST SAMPLE CONTAINS
lighter than Reference	less than 0.1 ppm detergent
same as Reference	1.0 ppm detergent
darker than Reference	more than 1.0 ppm detergent

7. Add one drop of DS Reference Solution (4513) to the Reference Sample Tube. Shake to mix. Compare the color as before. The color in the Reference Sample is now equal to 2.0 ppm. Continue this procedure, counting the number of drops of DS Reference Solution (45134) added, until the color of the bottom layer in each tube is the same. Each drop of the DS Reference Solution (4513) added to the Reference Sample Tube is equal to 1.0 ppm detergent in the sample.

   NOTE: If at any time, the top layer of the Test Sample or Reference Sample becomes colorless, add more DS Indicator Reagent (4508). The amount of this reagent added is not important as long as there is color in the top layer.

SAFETY



OBTAINING WATER SAMPLES

While collecting water samples, the major objectives are to be careful and to not fall into the water. You are more important than the sample. If possible, have someone go with you to watch in case of trouble. Sample your site from bridges with pedestrian walkways, from docks, or from stream banks. If the stream bank is steep, tie a rope to a stationary object to assist climbing up and down the banks. Do not enter the water. Approach your site carefully. Watch out for traffic, and park your vehicle off roads, out of traffic. Be aware of indengious life such as snakes, fire ants, wasps, bees, wild animals and poison ivy.

Water for testing in the classroom by students may be obtained using a bucket or beaker. The sampling container must be rinsed twice with the water to be sampled. For transport back to school, the container should be covered or the sample may be transferred to a container that can be closed. The transport container also needs to be rinsed twice with the sample water. Dissolved oxygen samples should be obtained separately at the sample site and fixed before transport.

MATERIAL SAFETY DATA SHEETS (MSDS)

MSDS sheets for all chemicals are included in each individual kit. Copies are provided in the Appendix of this manual.

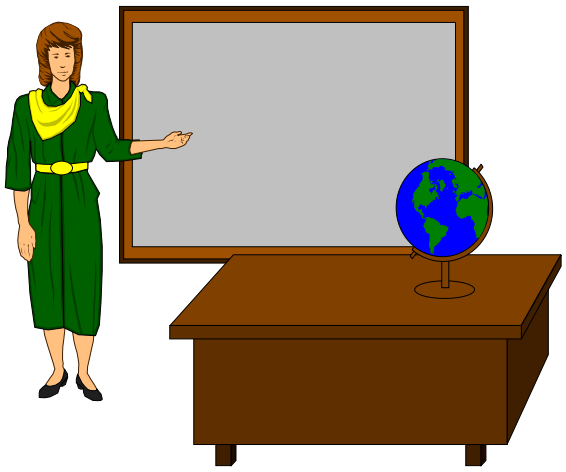
DISPOSAL OF REAGENTS

Follow any instructions on the MSDS sheets for proper disposal. Sample water with reagents can be disposed of in the sanitary sewage system.

LAB PROCEDURES

1. Read all instructions to familiarize yourself with the test procedures before you begin.
2. Read the label on each reagent container before use.
3. Familiarize yourself with the information on the material safety data sheet (MSDS) for each chemical.
4. Avoid contact between chemicals and one's skin, eyes, nose and mouth.
5. Wear safety goggles or glasses and rubber gloves when handling chemicals.
6. Use test tube caps or stoppers to cover test tubes during shaking and mixing.
   DO NOT USE FINGERS TO COVER THE TOP OF TEST TUBES.
7. Wipe up any chemical spills when they occur. Rinse the area with a wet sponge and dry the area.
8. When not in use, tightly cap all chemical containers.
9. When adding any reagents to the sample water, be sure not to touch the sample with the spoons or pipets.

SAMPLE LESSON PLANS



HOW WET IS OUR PLANET?

Topics for discussion

- Water Cycle
- Water conservation
- Distribution of water on earth

Materials

- Map of world
- 12 inch diameter globe
- 5 or 10 gallon aquarium
- calculator
- measuring cup
- quart container
- measuring tablespoon

Procedures

1. Conduct a general discussion with students on how much water is present on the earth. Discuss why the earth is called the water planet. Be sure to mention that between 2/3 and 3/4 of the surface of the planet is covered with water. Give the students the following statistics:

All numbers are in percent of total

Oceans	97.2
Icecaps/glaciers	2.0
Groundwater	0.62
Freshwater lakes	0.009

Inland lakes/salt lakes	0.008
Atmosphere	0.001
Rivers	0.0001

2. What percentage of the water (fresh) is potentially available for human use?

Groundwater	0.62
Freshwater lakes	0.009
Rivers	0.0001
Subtotal	0.6291
add icecaps/glaciers	2.0
Total	2.6291

Remember that the amount freshwater that is usable is reduced by pollution and other contamination. Also some groundwater may not be available and icecaps/glaciers are not a readily available source of water.

3. Using the aquariums, assume that 5 gallons of water represents all the water on earth (5 gallons = 1280 tablespoons). Calculate the volume of water quantities on the percentage list from number 1 in tablespoons.

5 gallons	
Oceans	1244.16
Icecaps/glaciers	26.24
Groundwater	7.93
Freshwater lakes	0.11
Inland seas/salt lakes	0.1
Atmosphere	0.0128
Rivers	0.0012
Total	1280 tablespoons

4. This can be done in small work groups.
   a. Have the students calculate the volume of water other than ocean water (about 34 tablespoons).
   b. Put this amount of water (34 tablespoons) in the quart container.
   c. Remove the amount of water that represents all freshwater lakes and rivers (about 0.111 tablespoons or 1/10 of a tablespoon).
   d. Remove the amount of water that represents rivers (1/1000 of a tablespoon or less than one drop). Discuss with students, the relative magnitude of the volume of water in rivers to the entire volume of water on the planet.

Discussion topic

How many species depend on this “drop” of water.

HOW DO YOU MEASURE UP?

Topics for discussion
- Water conservation
- Storm drainage system
- Water pollution

Score responses as follows:
- Never = 1
- Sometimes = 2
- Often = 3

Do you or anyone in your family:

1. Leave the tap water on when brushing your teeth or shaving?
2. Turn the lawn sprinkler on during mid-day?
3. Throw used containers of paint, solvents, into the trash without reading the label instructions?
4. Empty left over paints, solvents, or cleansers into the sink?
5. Empty left over paints, solvents, or cleansers in the street?
6. Run the washing machine or dishwasher with small loads?
7. Water your lawn frequently or run the automatic sprinkler system in the rain?
8. Use fertilizers or pesticides without reading the label instructions?
9. Wash down spilled fertilizers or pesticides on the sidewalk or street?
10. Leave the shower on to heat up the bathroom?
11. Use the toilet to dispose of ordinary waste?
12. Wash the car every weekend in the summer?
13. Change your oil in the street or use the storm drain to dispose of used oil?
14. Sweep grass clippings into the curb or down the storm drains?
15. Use the garbage disposal to get rid of food scraps?

How did you score?

20 or less
You are a valuable resource just like our water. Keep up the good work!!!!!!!

21 to 30
You are on your way to become a valuable resource, keep up the good work and try some additional ways to prevent water pollution and water conservation.

31 to 45
You might want to think about ways to modify some habits or join the fight against water pollution.

STORM DRAIN WATCH

Topics for discussion

- Nonpoint source pollution
- Function of a storm drain
- Preventing nonpoint source pollution

Materials

- Aquarium
- Water
- Cardboard box
- Food coloring
- Spray bottle
- Soil
- Sand
- Gravel
- Vegetable oil
- Cafeteria waste
- Trash
- Grass clippings
- Shredded paper
- Small sticks

Procedure

1. List on the chalkboard those pollutants that could enter a storm drain system. (Consider trash, fertilizer, oil, sand, soil, leaves, grass clippings, etc.). Discuss the purpose of a storm drain. Discuss nonpoint source pollution. Discuss how pollutants enter the storm drain system.

2. Make a storm drain.
   a. Fill the aquarium half full of water.
   b. Place the cardboard box on top of the box to represent an outfall pipe of a storm drainage system. The water in the aquarium represents the water system that the receives the water from the drainage system.

3. Now pollute your storm drain.
   a. Mr. Jones likes have a nice yard and trees. He sprays his lawn with a fertilizer to keep it green and uses insecticides to prevent insects. He believes in water conservation, so he waits until rain is forecast then he sprays his yard. The rain washes all the chemicals off his yard into the storm drain system.

      To represent the chemical, mix a few drops of green food coloring with water in a spray bottle. Spray the water into the storm drain.

b. A new mall is being built in town. The construction site does not have erosion control devices around the recently disturbed soil and it rains. All the loose soil leaves the construction site and enters the storm drain.

   Add loose soil.

c. Susan is so proud, not only can she drive, she can change her car's oil. She carries the used oil to the storm drain inlet and pours it in. The oil is gone.

   Add vegetable oil.

d. The Smith family put their trash bags out late one night. A roving cat tore into the trash and the garbage was strewn all over the yard. The Smith's got up late that morning and didn't clean up the mess. It rained that afternoon.

   Add samples of food waste and paper.

e. Mark mowed his family's yard to earn extra money. He dumped the clippings in the storm drainage channel behind his house. The clippings sat there turning yellow and smelling bad until the next rain.

   Add grass clippings.

f. Terry likes walking the family dog, Duke. Terry does not want Duke to defecate in the neighbor's yard, so Duke defecates in the street gutter. Terry doesn't worry though, it disappears during the next rain.

   Add small twigs.

g. Susan and Jimmy went to a fast food restaurant on the way to the lake. In order to keep the car clean, they threw the trash out the window.

   Add trash.

4. Points of discussion.
   How has the water changed color?
   Discuss where pollutants originate and where they come to rest.

OTHER EXPERIMENTS USING THE WATER QUALITY TEST KITS

pH

First, measure the pH of the water. Then have students blow into a glass of water using a straw (i.e., blow bubbles like a kid). Measure the pH after blowing into the water. What happened and why? Remember that carbon dioxide is given off during respiration. Carbon dioxide and water form a weak carbonic acid. Using the same beakers from the dissolved oxygen experiment below, also test the pH.

Dissolved Oxygen

Get a water plant such as duck weed. Assign each class a specific beaker. For each beaker of water, measure the DO. Place the plant in the water, then place plastic wrap around the beaker to prevent any air from entering the water. Place the beaker under a light source. Measure the DO again in 30 minutes. You might want the let this experiment go all day. Do not throw out the water in any of the beakers. Keep them overnight in the dark and measure again the next day.

Nitrogen

Get a couple of different plant fertilizers, organic or inorganic. Add one tablespoon to a quart of water (256 tablespoons = 1 quart). Test using the ammonia nitrogen kit. If it tests off the scale, dilute 1 part of solution to 9 parts water, for a 1:10 dilution. Test again. Repeat dilution, if necessary. Determine the ammonia concentration in the original sample water.

Detergents

Get a couple of different soaps, hand soap, laundry, dishwasher, etc. Add 1 tablespoon to a quart of water (256 tablespoons = 1 quart). Test using the detergent test kit. If the solutions test off the scale, dilute 1 part of solution to 9 parts of water for a 1:10 dilution. Test again. Repeat dilution, if necessary. Determine the detergent concentration in the original sample water.

SUPPLY LIST, SUPPLIERS AND PRICE LISTS

Posters

U.S. Geological Survey
Branch of Information Services
Box 25286
Denver Federal Center, MS 306
Denver, CO 80225

(800) 435-7627

price: free

Videos

Nonpoint Source Pollution Community/Rural

Lawrence & Schiller Incorporated
3932 South Willow Ave
P.O. Box 89307
Sioux Falls, SD 57105-6293

(800) 888-8470

price: $8.45

Trinity River Revival and *Urban Watch Storm Drain Field Test Kit Training Video*

Trinity River Authority of Texas
Public Relations Office
5300 South Collins
Arlington, Texas 76017

(817) 467-4343

price: $5.00

Testing Equipment

Thermometers, pH strips, and gloves

Scientific Industrial
3116 St. Louis
Fort Worth, Texas 76110

(817) 926-5437

price:	Thermometer (#T4265-2)	$ 9.20
	pH strips (#P1160-1)	8.50
	gloves (#G2740)	10.00

Safety Glasses

Forestry Suppliers
P.O. Box 8397
Jackson, MS 39284-8397

(800) 647-5368

price: $1.70 to $1.30 depending on size of order (#23255)

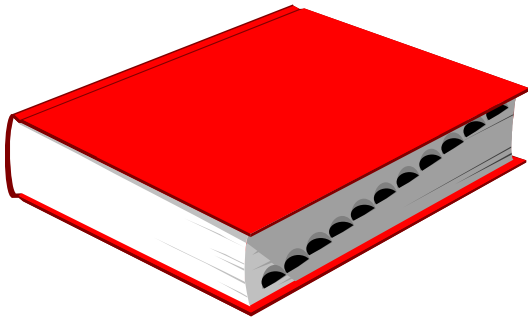
LaMotte Kits and replacement reagents

CDC Global Enterprises
6850 Manhattan Blvd.
Fort Worth, Texas 76120

(800) 345-4681
(817) 345-4681

Chlorine	# 3308	$29.60
	# r3308	7.97
Detergent	# 4507	25.35
	# r4507	15.85
Dissolved oxygen	# 7414	26.20
	# r7414	12.40
Nitrogen	# 5864	24.15
	# r5864	7.78

GLOSSARY



accuracy - a measure of how close repeated trials are to the true value.

acidity - a measure of the number of free hydrogen ions (H+) in a solution that can chemically react with other substances.

acute toxicity - immediate danger or death due to a toxic substance.

algae - chlorophyll containing plants, ranging from unicellular to multicellular forms, occurring in fresh or salt water.

alkalinity - a measure of the negative ions that are available to react and neutralize free hydrogen ions.

ambient - pertaining to the current environmental condition.

aquatic system - all biological and chemical components of a body of water.

assemblage - the set of related organisms that represent a portion of a biological community.

bacteria - microscopic spherical, rod-shaped or spiral organisms that are concerned with fermentation, putrefaction and the production of disease.

benthic - pertaining to the bottom (bed) of a water body.

best management practice (BMP) - Any type of practice or management style that is designed to protect water quality by controlling the processes of erosion, runoff, nutrients, pesticides and toxics.

bioaccumulate - accumulation of a pollutant in the tissue of biological organisms.

biochemical oxygen demand (BOD) - the amount of oxygen needed by microorganisms to break down waste in the water.

biodegradable - capable of being decomposed by natural processes.

biodiversity - diversity or variety of living organisms.

bloom - accelerated growth of algae due to extra nutrients in the water.

channel - the section of the stream that contains the main flow.

channelization - the process of artificially modifying, reshaping or straightening a stream channel.

chronic toxicity - the toxic substance causes long term effects in organisms.

combined sewer overflow (CSO) - sewer systems in which sanitary waste and storm water are combined in heavy rains. The discharge from CSO's is generally untreated.

community - the whole of the plant and animal population inhabiting a given area.

conservation - wise use of natural resources that ensures their continuing use for future generations.

consumer - a person or thing that consumes, uses something up or uses a commodity of service. In a food chain, the consumer is an organism that has to eat other organisms for food. An organism can not manufacture it own food.

contamination - the act of rendering something impure or unsuitable by contact or Mixture with something unclean, i.e., a pollutant.

culvert - a man-made structure that carries for a short distance the natural flow of water through or under something such as a road or an embankment.

decomposer - bacteria and other non-photosynthetic organisms (such as fungi and worms) which consume dead organic material and causes this material to break down or decompose.

deionized water - water that has had all of the ions (atoms or molecules) other than hydrogen and oxygen removed.

designated uses - state established desirable uses that waters should support, such as fishing, swimming and aquatic life.

detritus - freshly dead or partially decomposed organic matter which serves as a base for the food chain.

dissolved oxygen (DO) - oxygen dissolved in water and available for living organisms to use for respiration.

distilled water - water that has had most of its impurities removed.

ecoregion - geographic areas that are distinguished from others by ecological characteristics such as climate, soils, geology and vegetation.

ecosystem - system of interrelated organisms and the physical and chemical environment.

effluent - any treated or untreated liquid waste that enters the environment from a specific (point) source. Usually associated with wastewater discharges or liquid industrial waste.

emergent plants - plants rooted underwater, but with their tops extending above the water.

environment - the aggregate of surrounding things, conditions or influences.

epilimnion - warmer uppermost layer of a lake during thermal stratification.

erosion - the process by which a land surface is gradually worn away. Usually due to a force of nature; i.e., wind, waves, or flowing water.

eutrophic - bodies of water with large concentrations of mineral and organic nutrients resulting in an environment that favors plant over animal life.

eutrophication - the natural and artificial addition of nutrients to a water body, which may lead to depleted oxygen concentrations. Eutrophication is a natural process that is frequently accelerated and intensified by human activities.

fecal coliform - bacteria normally found in the colon of most warm blooded animals. Used for an indicator of pollution and the possible presence of waterborne pathogens.

fertilizer - a substance that enriches the soil with nutrients.

floating plants - plants that grow free floating rather than being attached to the stream bed.

floc - a mass of particles that form into a clump as a result of a chemical reaction.

food chain - a series of organisms interrelated by their habit of feeding one upon another.

glide/run - section of a stream with low velocity and with little or no turbulence at the surface of the water.

gross morphological features - large obvious identifying physical characteristics of an organism.

groundwater - water located beneath the surface of the ground within the void spaces of the soil or strata.

habitat - native environment for a species.

hazardous waste - any waste that is a threat to human life, living organisms or the environment.

headwater - the origin of a stream. Also, the water from which a stream rises.

hypolimnion - cooler bottom layer of a lake during thermal stratification.

hypoxia - depletion of dissolved oxygen in an environment.

impairment - degradation.

impoundment - a body of water contained by a barrier such as a pond, lake or reservoir.

inert - not chemically or physically active.

land uses - activities that take place on the land.

macroinvertebrate - organisms that lack a backbone and can be seen with the naked eye.

mainstream - the prevailing current or direction of movement in a stream, river or estuary.

monitoring - observing, recording, collecting or detecting a condition with instrumentation or test.

microbes -a minute life form, especially a disease causing microorganism.

nonpoint source pollution - pollution from diffuse sources. Generally initiated by storm water runoff from all types of land use.

NPDES - National Pollutant Discharge Elimination System. A national program in which pollution from discharges from point sources such as sewage treatment plants have permits to discharge water from their facilities. The permits list limitations on the amount and type of pollutants the facilities are allowed to discharge.

nutrients - substance used by living organisms that promotes growth.

orthophosphate - inorganic phosphate dissolved in water.

outfall - the end of a pipe or channel from which storm water enters a waterbody. May be associated with the discharge location of a point source such an industrial facility or wastewater treatment plant effluent.

pathogen - an organism that can cause diseases.

pesticide - substance or mixture of substances intended for preventing, destroying, or repelling any pest.

pH - a measure of the acidity of a substance. Scale of 1.0 (acid) to 14.0 (basic).

phosphorus - a nutrient that is essential for plants and animals.

photosynthesis - the process by which plants convert light into chemical energy and synthesize organic compounds from inorganic compounds.

point source pollution - pollution from any single identifiable source.

pollutant - any substance that can harm or adversely affect the environment or a resource.

producer - any organism that makes its own food through photosynthesis.

reagent - a substance or chemical used to indicate the presence of a chemical or to induce a chemical reaction to determine the chemical characteristics of a solution.

runoff - water that drains or flows over land. The portion of rainfall, melted snow or irrigation water that flows across the land's surface, does not soak into the ground and eventually runs into bodies of water.

sediment - Soil, sand and minerals that are washed from land areas into water.

submergent plants - plants that live and grow fully submerged under the water.

tolerance - the ability to withstand a particular condition, i.e., pollution tolerant indicates that ability to live in polluted waters.

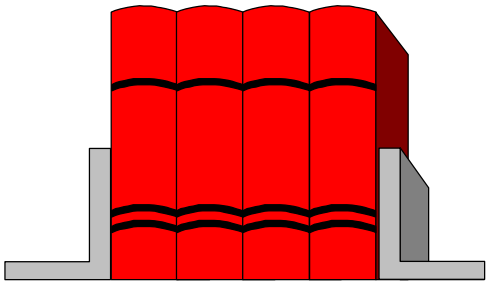
tributary - a river or stream flowing into a larger river or stream.

turbidity - murkiness or cloudiness of water.

USEPA - United States Environmental Protection Agency.

watershed - the area of land drained by a particular river or stream system.

REFERENCES AND SUGGESTED READINGS



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APPENDIX

The following pages are the Material Safety Data Sheets (MSDS) for the reagents in the water quality testing kits.

MATERIAL SAFETY DATA SHEET

LAMOTTE COMPANY
PO BOX 329 • CHESTERTOWN • MARYLAND • 21620
TELEPHONE # FOR INFORMATION 410-778-3100
IN AN EMERGENCY: LOCAL POISON CONTROL CENTER

I • PRODUCT IDENTIFICATION

Name: Alkaline Potassium Iodide Azide *Code #:* 7166

II • HAZARDOUS INGREDIENTS

Name	*CAS #*	*%*	*PEL*	*TLV*
Potassium Hydroxide	1310-58-3	60	N/A	C2 mg/m^3
Sodium Azide	26628-22-8	<1	C 0.3 mg/m^3	C 0.1 ppm

III • NON-HAZARDOUS INGREDIENTS EXCEPT WATER (7732-18-5)

Name	*CAS#*	*%*
Potassium Iodide	7681-11-0	14

IV • PHYSICAL DATA

Appearance: Clear, colorless liquid *Odor:* None

Solubility in water: Soluble *pH:* 14

Boiling point: Unknown *Melting point:* N/A

Vapor pressure (mmHg): Unknown *Vapor Density (Air=1):* Unknown

V • FIRE & EXPLOSION DATA

Flash point (method used): N/A

Flammable limit: LEL: N/A *UEL:*N/A

Extinguishing Media: Not a fire hazard

Special Fire Fighting Procedures: N/A

Unusual Fire & Explosion Hazard: N/A

VI • REACTIVITY DATA

Stability: Stable [X] Unstable [ ]

Conditions to Avoid: Contact with Acids

Incompatibility (Materials to Avoid): Acids, metals

Hazardous Decomposition Products: N/A

VII • HEALTH HAZARD DATA

Toxicity: Unknown

Primary Route of Entry: Inhalation [ ] Skin [X] Ingestion [ ]

Target Organ: N/A

Signs & Symptoms of Exposure: Severe burns, may be fatal if swallowed

Medical Condition Aggravated by Exposure: N/A

Carcinogenicity: [ ] NTP [ ] IARC [X] N/A [ ] OSHA

VIII • EMERGENCY FIRST AID PROCEDURES

Eye Contact: Immediately flush with water for 15 minutes. Consult physician.

Skin Contact: Immediately flush with water, remove affected clothing and flush skin for 15 minutes.

Ingestion: Do not induce vomiting. Rinse mouth, drink plenty of water and consult physician immediately.

Inhalation: N/A

IX • SPILL & DISPOSAL PROCEDURES

Spill & Leak: Neutralize carefully with 6M-HCl. Collect waste. Dispose as hazardous waste according to federal, state and local regulations.

Disposal: Dispose as hazardous waste according to federal, state and local regulations.

X • PRECAUTIONARY MEASURES

In Handling: Gloves [X] Eye Protection [X] Other: Lab Coat

Ventilation: Normal [X]Mechanical [ ] Respiratory Protection [ ]

Work/Hygienic Practices: Avoid contact with skin and clothing

XI • SPECIAL PRECAUTIONS: N/A

DATE: 8/17/94

The above information is believed to be correct but does not claim to be all inclusive and should be used only as a guide.

†This is a toxic chemical subject to reporting requirements of section 313 of EPCRA and 40CFR372.

MATERIAL SAFETY DATA SHEET

LaMOTTE COMPANY
PO BOX 329 • CHESTERTOWN • MARYLAND • 21620
TELEPHONE # FOR INFORMATION: 410/778-3100
IN AN EMERGENCY, DIAL POISON CONTROL CENTER

I • PRODUCT IDENTIFICATION

Name: Ammonia #1 Tablets *Code #*: 3968

II • HAZARDOUS INGREDIENTS

Name	*CAS #*	*%*	*PEL*	*TLV*
†Sodium Nitroferricyanide dihydrate	13755-38-9	<10	5 mg/m^3 as CN	5 mg/m^3 as CN
Sodium Salicylate	54-21-7	<50	N/E	N/E

III • NON-HAZARDOUS INGREDIENTS EXCEPT WATER (7732-18-5)

Name	*CAS#*	*%*
All other ingredients are proprietary, NJTSRN 80100291-5032p		

IV • PHYSICAL DATA

Appearance: White tablet with red spots *Odor*: None

Solubility in water: Soluble *pH*: 9 (one tablet in 5 mL water)

Boiling point: N/A *Melting point*: Unknown

Vapor pressure (mmHg): N/A *Vapor Density (Air=1)*: N/A

V • FIRE & EXPLOSION DATA

Flash point (method used): N/A

Flammable limits: LEL: N/A *UEL*: N/A

Extinguishing Media: Not a fire hazard

Special Fire Fighting Procedures: N/A

Unusual Fire & Explosion Hazard: May produce poisonous cyanide fumes under fire conditions.

VI • REACTIVITY DATA

Stability: Stable[X] Unstable[ ]

Conditions to Avoid: Moisture, heat. Avoid temperatures above 190°C

Incompatibility (Materials to Avoid): Acids, strong oxidizers

Hazardous Decomposition Products: NO_x, HCN gas

VII • HEALTH HAZARD DATA

Toxicity: orl rat LD50: 99 mg/kg for sodium nitroferricyanide

Primary Route of Entry: *Inhalation*[ ] *Skin*[ ] *Ingestion*[X] *N/A*[ ]

Target Organ: N/A

Signs & Symptoms of Exposure: Harmful if swallowed, inhaled or absorbed through skin. May cause headache, vomiting, convulsions.

Medical Condition Aggravated by Exposure: N/A

Carcinogenicity: *N/A*[X] *NTP*[ ] *IARC*[ ] *OSHA*[ ]

VIII • EMERGENCY FIRST AID PROCEDURES

Eye Contact: Wash with water for 15 minutes. Consult physician.

Skin Contact: Wash with water for 15 minutes. Consult physician.

Ingestion: Induce vomiting. Drink plenty of water. Consult physician immediately.

Inhalation: Remove to fresh air.

IX • SPILL & DISPOSAL PROCEDURES

Spill & Leak: Small quantity: Sweep up tablets. Dissolve in water and wash down drain with excess water. Large quantity: Sweep up. Place in a clean, dry, sealed container and send to hazardous waste incinerator.

Disposal: Dispose of as hazardous waste according to federal, state and local regulations.

X • PRECAUTIONARY MEASURES

In Handling: Gloves[X] *Eye Protection*[X] *N/A*[ ] *Other* Lab Coat

Ventilation: Normal[X] *Mechanical*[ ] *Respiratory Protection*[ ]

Work/Hygienic Practices: Avoid handling tablets.

XI • SPECIAL PRECAUTIONS: N/A

DATE: 11/5/94

The above information is believed to be correct but does not claim to be all inclusive and should be used only as a guide.

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MATERIAL SAFETY DATA SHEET

LaMOTTE COMPANY
PO BOX 329 • CHESTERTOWN • MARYLAND • 21620
TELEPHONE # FOR INFORMATION 410-778-3100
IN AN EMERGENCY: LOCAL POISON CONTROL CENTER

I • PRODUCT IDENTIFICATION

Name: Sulfamic Acid Powder *Code #:* 6286

II • HAZARDOUS INGREDIENTS

Name	*CAS #*	*%*	*PEL*	*TLV*
Sulfamic Acid	5329-14-6	100	N/E	N/E

III • NON-HAZARDOUS INGREDIENTS EXCEPT WATER [7732-18-5]

Name	*CAS#*	*%*
N/A		

IV • PHYSICAL DATA

Appearance: White crystals *Odor:* None

Solubility in water: Soluble *pH:* 1 (0.1 g in 10mL water)

Boiling point: N/A *Melting point:* Unknown

Vapor pressure (mmHg): N/A *Vapor Density (Air=1):* N/A

V • FIRE & EXPLOSION DATA

Flash point (method used): N/A

Flammable limit: LEL: N/A *UEL:* N/A

Extinguishing Media: Dry chemical, alcohol foam, CO_2

Special Fire Fighting Procedures: N/A

Unusual Fire & Explosion Hazard: N/A

VI • REACTIVITY DATA

Stability: Stable[X] Unstable[ ]

Conditions to Avoid: Heating while confined

Incompatibility (Materials to Avoid): Strong oxidizers and bases

Hazardous Decomposition Products: SO_x

VII • HEALTH HAZARD DATA

Toxicity orl rat LD50: 3160 mg/kg

Primary Route of Entry: Inhalation[X] Skin[X] Ingestion[ ] N/A[ ]

Target Organ: N/A

Signt & Symptoms of Exposure: Irritating to eyes, skin and mucous membranes.

Medical Condition Aggravated by Exposure: N/A

Carcinogenicity: N/A[X] NTP[ ] IARC[ ] OSHA [ ]

VIII • EMERGENCY FIRST AID PROCEDURES

Eye Contact: Flush with water for 15 minutes. Contact a physician.

Skin Contact: Wash with soap and water. Remove all effected clothing and wash skin thoroughly. Consult a physician.

Ingestion: Give plenty of water. Consult a physician.

Inhalation: Remove to fresh air.

IX • SPILL & DISPOSAL PROCEDURES

Spill & Leak: Sweep up, dissolve in water. Wash down drain with excess water.

Disposal: Dissolve in water. Wash down drain with excess water. Dispose according to federal, state and local regulations.

X • PRECAUTIONARY MEASURES

In Handling: Gloves[X] Eye Protection[X] N/A [ ]Other Lab Coat

Ventilation: Normal [ ] Mechanical [X] Respiratory Protection[ ]

Work/Hygienic Practices: Avoid contact with skin and clothing.

XI • SPECIAL PRECAUTIONS: Use adequate ventilation.

DATE: 9/24/93

The above information is believed to be correct but does not claim to be all inclusive and should be used only as a guide.

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MATERIAL SAFETY DATA SHEET

LaMOTTE COMPANY
PO Box 329 • CHESTERTOWN • MARYLAND • 21620
TELEPHONE # FOR INFORMATION 410-778-3100
IN AN EMERGENCY: LOCAL POISON CONTROL CENTER

I • PRODUCT IDENTIFICATION

Name: DS Indicator Reagent *Code #*: 4508

II • HAZARDOUS INGREDIENTS

Name	*CAS #*	*%*	*PEL*	*TLV*
†Toluene	108-88-3	> 99.9	377 mg/m^3	100 ppm

III • NON-HAZARDOUS INGREDIENTS EXCEPT WATER (7732-18-5)

Name	*CAS#*	*%*
Bromphenol Blue	115-39-9	< 0.1

IV • PHYSICAL DATA

Appearance: Blue Liquid *Odor*: Aromatic

Solubility in water:Very slight *pH*: N/A

Boiling point:231°F *Melting point*: N/A

Vapor pressure (mmHg):22 at 68°F *Vapor Density (Air=1)*: 3.1

V • FIRE & EXPLOSION DATA

Flash point (method used): 40°F (closed cup)

Flammable limits: *LEL*: 1.2% *UEL*: 7.1%

Extinguishing Media: Dry chemical or CO_2 extinguishers, water spray.

Special Fire Fighting Procedures: Wear goggles and self contained breathing apparatus.

Unusual Fire & Explosion Hazard: Vapor is heavier than air & may travel considerable distance to a source of ignition and flash back.

VI • REACTIVITY DATA

Stability: Stable[X] Unstable[ ]

Conditions to Avoid: Heat and sources of ignition

Incompatibility (Materials to Avoid): Strong oxidizers

Hazardous Decomposition Products: N/A

VII • HEALTH HAZARD DATA

Toxicity: inl hmn TCLo 200 ppm

Primary Route of Entry: Inhalation[X] Skin[ ] Ingestion[X] N/A[ ]

Target Organ: Kidney, liver, skin, central nervous system

Signs & Symptoms of Exposure: Eye and respiratory irritant. Inhalation of vapors may cause death by paralysis of respiratory center. May be fatal if swallowed.

Medical Condition Aggravated by Exposure: Respiratory conditions

Carcinogenicity: N/A[X] NTP[ ] IARC[ ]

VIII • EMERGENCY FIRST AID PROCEDURES

Eye Contact: Immediately flush with water for 15 minutes. Consult a physician.

Skin Contact: Remove all affected clothing and rinse skin thoroughly. Consult physician.

Ingestion: Do not induce vomiting. Immediately call physician.

Inhalation: Remove to fresh air and give artificial respiration if breathing has stopped.

IX • SPILL & DISPOSAL PROCEDURES

Spill & Leak: Eliminate all sources of ignition and flammables. Absorb on inert material (kitty litter) or spill pads. Place in clean, dry plastic pail and allow to evaporate in fume hood.

Disposal: Small Quantity-evaporate in fume hood. Large quantity-atomize into an incinerator. Dispose according to federal, state and local regulations.

X • PRECAUTIONARY MEASURES

In Handling: Gloves[X] Eye Protection[X] N/A [ ]Other Lab Coat

Ventilation: Normal [ ] Mechanical [X] Respiratory Protection[ ]

Work/Hygienic Practices: Use adequate ventilation.

XI • SPECIAL PRECAUTIONS: Store away from source of ignition. Avoid contact with skin and inhalation of vapor.

DATE: 5/5/94

The above information is believed to be correct but does not claim to be all inclusive and should be used only as a guide.

† This is a toxic chemical subject to reporting requirements of section 313 of EPCRA and 40CFR372.

MATERIAL SAFETY DATA SHEET

LAMOTTE COMPANY
PO BOX 329 • CHESTERTOWN • MARYLAND • 21620
TELEPHONE # FOR INFORMATION 410-778-3100
IN AN EMERGENCY: LOCAL POISON CONTROL CENTER

I • PRODUCT IDENTIFICATION

Name: Alkaline Potassium Iodide Azide *Code #:* 7166

II • HAZARDOUS INGREDIENTS

Name	*CAS #*	*%*	*PEL*	*TLV*
Potassium Hydroxide	1310-58-3	60	N/A	C2 mg/m^3
Sodium Azide	26628-22-8	<1	C 0.3 mg/m^3	C 0.1 ppm

III • NON-HAZARDOUS INGREDIENTS EXCEPT WATER (7732-18-5)

Name	*CAS#*	*%*
Potassium Iodide	7681-11-0	14

IV • PHYSICAL DATA

Appearance: Clear, colorless liquid *Odor:* None

Solubility in water: Soluble *pH:* 14

Boiling point: Unknown *Melting point:* N/A

Vapor pressure (mmHg): Unknown *Vapor Density (Air=1):* Unknown

V • FIRE & EXPLOSION DATA

Flash point (method used): N/A

Flammable limit: LEL: N/A *UEL:*N/A

Extinguishing Media: Not a fire hazard

Special Fire Fighting Procedures: N/A

Unusual Fire & Explosion Hazard: N/A

VI • REACTIVITY DATA

Stability: Stable [X] Unstable [ ]

Conditions to Avoid: Contact with Acids

Incompatibility (Materials to Avoid): Acids, metals

Hazardous Decomposition Products: N/A

VII • HEALTH HAZARD DATA

Toxicity: Unknown

Primary Route of Entry: Inhalation [ ] Skin [X] Ingestion [ ]

Target Organ: N/A

Signs & Symptoms of Exposure: Severe burns, may be fatal if swallowed

Medical Condition Aggravated by Exposure: N/A

Carcinogenicity: [ ] NTP [ ] IARC [X] N/A [ ] OSHA

VIII • EMERGENCY FIRST AID PROCEDURES

Eye Contact: Immediately flush with water for 15 minutes. Consult physician.

Skin Contact: Immediately flush with water, remove affected clothing and flush skin for 15 minutes.

Ingestion: Do not induce vomiting. Rinse mouth, drink plenty of water and consult physician immediately.

Inhalation: N/A

IX • SPILL & DISPOSAL PROCEDURES

Spill & Leak: Neutralize carefully with 6M-HCl. Collect waste. Dispose as hazardous waste according to federal, state and local regulations.

Disposal: Dispose as hazardous waste according to federal, state and local regulations.

X • PRECAUTIONARY MEASURES

In Handling: Gloves [X] Eye Protection [X] Other: Lab Coat

Ventilation: Normal [X]Mechanical [ ] Respiratory Protection [ ]

Work/Hygienic Practices: Avoid contact with skin and clothing

XI • SPECIAL PRECAUTIONS: N/A

DATE: 8/17/94

The above information is believed to be correct but does not claim to be all inclusive and should be used only as a guide.

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MATERIAL SAFETY DATA SHEET

LaMOTTE COMPANY
PO BOX 329 • CHESTERTOWN • MARYLAND • 21620
TELEPHONE # FOR INFORMATION 410-778-3100
IN AN EMERGENCY: LOCAL POISON CONTROL CENTER

I • PRODUCT IDENTIFICATION

Name: Sodium Thiosulfate, .025 N *Code #*: 4169

II • HAZARDOUS INGREDIENTS

Name	*CAS #*	*%*	*PEL*	*TLV*
Sodium Hydroxide	1310-73-2	.04	N/E	N/E

III • NON-HAZARDOUS INGREDIENTS EXCEPT WATER (7732-18-5)

Name	*CAS#*	*%*
Sodium Thiosulfate	10102-17-7	.68

IV • PHYSICAL DATA

Appearance: Clear, colorless liquid *Odor*: None

Solubility in water: Soluble *pH*: 12

Boiling point: unknown *Melting point*: unknown

Vapor pressure (mmHg): ~17@20°C *Vapor Density (Air=1)*: ~1

V • FIRE & EXPLOSION DATA

Flash point (method used): N/A

Flammable limit: LEL: N/A, *UEL*: N/A

Extinguishing Media: Not a fire hazard

Special Fire Fighting Procedures: N/A

Unusual Fire & Explosion Hazard: N/A

VI • REACTIVITY DATA

Stability: Stable[X] Unstable[ ]

Conditions to Avoid: N/A

Incompatability (Materials to Avoid): N/A

Hazardous Decomposition Products: N/A

VII • HEALTH HAZARD DATA

Toxicity: unknown

Primary Route of Entry: Inhalation[ ] Skin[X]Ingestion[ ] N/A[ ]

Target Organ: N/A

Signs & Symptoms of Exposure: May be irritating to skin.

Medical Condition Aggravated by Exposure: N/A

Carcinogenicity: N/A[X] NTP[ ] IARC[ ] OSHA [ ]

VIII • EMERGENCY FIRST AID PROCEDURES

Eye Contact: Flush with water for 15 minutes.

Skin Contact: Wash with soap and water.

Ingestion: Give plenty of water. Consult a physician.

Inhalation: N/A

IX • SPILL & DISPOSAL PROCEDURES

Spill & Leak: Neutralize with vinegar or other dilute acid and mop up.

Disposal: Pour into a large container of water and neutralize with acid. Wash down drain with excess water.

X • PRECAUTIONARY MEASURES

In Handling: Gloves[X] Eye Protection[X] N/A [ ]Other Lab Coat

Ventilation: Normal [X] Mechanical [ ] Respiratory Protection[ ]

Work/Hygienic Practices: Avoid contact with skin.

XI • SPECIAL PRECAUTIONS: N/A

DATE: 6/13/94

The above information is believed to be correct but does not claim to be all inclusive and should be used only as a guide.

†This is a toxic chemical subject to reporting requirements of section 313 of EPCRA and 40CFR372.

MATERIAL SAFETY DATA SHEET

LaMOTTE COMPANY
PO BOX 329 • CHESTERTOWN • MARYLAND • 21620
TELEPHONE # FOR INFORMATION 410-778-3100
IN AN EMERGENCY: LOCAL POISON CONTROL CENTER

I • PRODUCT IDENTIFICATION

Name: Ammonia #2 Tablets *Code #*: 3969

II • HAZARDOUS INGREDIENTS

Name	*CAS #*	*%*	*PEL*	*TLV*
Lithium Hydroxide monohydrate	1310-66-3	<30	N/E	N/E
Lithium Hypochlorite	13840-33-0	<20	N/E	N/E
Lithium Carbonate	554-13-2	<0.3	N/E	N/E

III • NON-HAZARDOUS INGREDIENTS EXCEPT WATER (7732-18-5)

Name	*CAS#*	*%*
All other ingredients are proprietary, NJTSRN 80100291-5033p		

IV • PHYSICAL DATA

Appearance: White tablet *Odor*: Bleach

Solubility in water:Soluble *pH*:13 (one tablet in 5 mL water)

Boiling point:N/A *Melting point*: N/A

Vapor pressure (mmHg):N/A *Vapor Density (Air=1)*: N/A

V • FIRE & EXPLOSION DATA

Flash point (method used): N/A

Flammable limit: LEL: N/A *UEL*: N/A

Extinguishing Media: Not a fire hazard

Special Fire Fighting Procedures: Fire fighters wear SCBA

Unusual Fire & Explosion Hazard: Emits toxic fumes under fire conditions

VI • REACTIVITY DATA

Stability: Stable[X *] Unstable[ ]*

Conditions to Avoid: Moisture, heat

Incompatibility (Materials to Avoid): Strong acids, oxidizable materials

Hazardous Decomposition Products: Chlorine gas

VII • HEALTH HAZARD DATA

Toxicity: Lithium Carbonate is listed by the state of California as a reproductive toxin.

Primary Route of Entry: Inhalation[X *] Skin[* X *]Ingestion[* X *] N/A[ ]*

Target Organ: Skin, respiratory system, eye irritant.

Signs & Symptoms of Exposure: Corrosive. Irritating to eyes, skin nose, throat, respiratory system. Harmful if swallowed.

Medical Condition Aggravated by Exposure: N/A

Carcinogenicity: N/A[X *] NTP[ ] IARC[ ] OSHA[ ]*

VIII • EMERGENCY FIRST AID PROCEDURES

Eye Contact: Wash with water for 15 minutes. Consult physician.

Skin Contact: Wash with water for 15 minutes. Consult physician.

Ingestion: Do not induce vomiting. Drink plenty of water. Consult physician immediately.

Inhalation: Remove to fresh air.

IX • SPILL & DISPOSAL PROCEDURES

Spill & Leak: Small quantity: Dissolve in a beaker of water. Neutralize carefully with 6M HCl. Flush down drain with excess water. Large quantity: Sweep up. Avoiding raising dust. Containerize for disposal as hazardous waste. If spilled material is contaminated with moisture, organic matter, or other chemicals, do not tightly seal container. Isolate container in well ventilated area until disposal.

Disposal: Dispose as hazardous waste according to federal, state and local regulations.

X • PRECAUTIONARY MEASURES

In Handling: Gloves[X *] Eye Protection[* X *] N/A [ ]Other* Lab Coat

Ventilation: Normal [X *] Mechanical [ ] Respiratory Protection[ ]*

Work/Hygienic Practices: Avoid handling tablets.

XI • SPECIAL PRECAUTIONS: N/A

DATE: 9/30/94

The above information is believed to be correct but does not claim to be all inclusive and should be used only as a guide.

†This is a toxic chemical subject to reporting requirements of section 313 of EPCRA and 40CFR372.